Aquatic Habitat Restoration on the Lower Missouri River

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Abstract

The Missouri River was altered greatly during the past several decades to establish and maintain a navigation channel and to provide flood protection between Sioux City and the mouth near St. Louis. The construction of numerous structures, the closing of many side channels, and the creation of channel cut-offs has created a narrower, steeper, and higher velocity river. This has adversely affected the biological diversity of the river itself and riparian areas due to the loss of aquatic habitat. The Kansas City District has been working with other stakeholders to fulfill the mandate of the Water Resources Development Act and to comply with the U.S. Fish and Wildlife Service biological opinion regarding the Endangered Species Act. The goals of these projects are to restore additional shallow water habitat while still maintaining a channel suitable for navigation. Shallow water habitat has been created by altering existing structures, creating new side chutes, and reopening remnant chutes. The Overton Bottoms Mitigation Site provides a case study for the types of projects that support the mitigation effort by increasing the diversity and amount of aquatic habitat that exist along the Missouri River.

Background and Purpose

To ensure compliance with the Endangered Species Act, in 2000 the Corps initiated consultations with the U.S. Fish and Wildlife Service (USFWS) to determine if the operation of the Missouri Main Stem Reservoir System, the Missouri River Bank Stabilization and Navigation Project (BSNP), and the Kansas River Reservoir System jeopardize the continued existence of any federally listed species. Through the consultation process, it was determined that the current operation plan of the BSNP jeopardizes the existence of the Pallid Sturgeon. One component of recovery for the Pallid Sturgeon is the creation and restoration of shallow, low velocity habitat on the Missouri River below Sioux City, Iowa.

The major funding source for shallow water habitat (SWH) restoration is the expanded Missouri River Fish and Wildlife Mitigation Project authorized by the Water Resources Development Act of 1999. The purpose of the project is to mitigate fish and wildlife losses associated with construction of the BSNP. The act authorized the restoration of a total of 154,750 acres of terrestrial habitat and 12,000 acres of aquatic habitat. Two Corps districts are involved, with the Omaha District managing all projects in Iowa and Nebraska, and the Kansas City District managing all projects in Missouri and Kansas. The land utilized for this project is owned either by state governments, the U.S. Fish and Wildlife Service, or the Corps.

To build the BSNP, the corps constructed over 5,000 rock and piling river training structures to constrict the river's flow into a narrow self-scouring navigation channel. The result is that the river below Sioux City, Iowa is now narrower, swifter, and less diverse than the pre-project condition. The criteria for restored SWH are a velocity of less than 2 ft/sec and a depth of less than 5 feet during the median August flow (USFWS 2000). Historically, approximately 100 acres of this type of habitat were found for every mile of river. Currently, only approximately 1.4 acres of SWH per mile exist from Kansas City to the Grand River at river mile 250, and there are 18.3 acres per mile from the Grand River to the Osage River at river mile 130 (USACE 2003). The Corps goal is to restore up to 30 acres of shallow water habitat per river mile.

Missouri River Aquatic Habitat Restoration

The overall restoration goal is to benefit the Pallid Sturgeon by increasing the amount and diversity of SWH available while still maintaining a reliable navigation channel. Several methods have been used to create additional shallow water habitat along the Missouri River. These have included side channel excavation, structure modifications, and construction of new river training structures. Computer modeling has aided in the study and design of these projects.

Many stream restoration techniques call for the use of a 'reference reach', which is a part of the stream being studied or another stream than has the characteristics desired for the stream being restored (Soar and Thorne 2001). Due to the intense modification of the Missouri River during the past 60 plus years, the use of a reference reach may not be entirely realistic. However, there are reaches on the lower Missouri River that have large, open sandbars and side channels that favor endangered species with minimal historical navigation problems. One of these locations is Portland Bend, from river mile 114 to 116. This reach is characterized by a wooded island and sand bar complex along the right bank and a stable navigation channel along the left bank. Two-dimensional modeling of this reach is being performed to estimate the effects of dike modifications or bank movement on flow conditions in the navigations channel.

Structure Modifications

Existing training structures (dikes and revetments) have been modified by lowering, raising, or extending them in an effort to redirect flow into areas outside the navigation channel. These redistributed flows are intended to either simply diversify existing off-channel habitat or diversify and increase the amount of such habitat. The preferred modification is the notch, and approximately 270 have been placed on structures from Rulo, Nebraska to the mouth. Smaller notches (50 ft wide, 3 ft below normal navigation) placed away from the bank will diversify existing habitat, while larger notches (100 ft wide, 5 ft below normal navigation) placed immediately adjacent or into the bank will erode the bank and increase the amount of habitat.

Notches can be used in conjunction with dike extensions or dike raising. Used together, the intent is to create diverse off-channel sandbar and side channel complexes together with a reliable navigation channel. These techniques have shown success in several places, namely Plowboy Bend at river mile 171 and Jameson Island at river mile 214.

Changes have also been made to levees along the river. Levees have been rebuilt farther inland from the river to allow for additional overbank area during high flows and to provide space for bank degradation to occur. The old levees have been breached or removed which will result in a larger riparian area that may include seasonal wetlands. This has only been performed at locations where conditions allow and existing infrastructure will not be impacted.

Chute Construction

Continuously flowing side channels have been constructed on several state and federal mitigation sites in Missouri, Iowa, and Nebraska by the Omaha and Kansas City Districts. These chutes allow water to be diverted from the main channel and flow through newly constructed channels or re-excavated remnant channels. These chutes have been designed with the expectation that each will widen to a stable geometry after the initial excavation.

Case Study: Overton Bottoms Mitigation Site

The Overton Bottoms Mitigation Site provides examples of each of these techniques. The Missouri Department of Conservation and the U.S. Fish and Wildlife Service jointly manage this site, which is owned primarily by the Corps. It consists of 5,300 floodplain acres that were formerly agricultural land and approximately 10 miles of Missouri River frontage. Some of the site is part of the Big Muddy National Wildlife Refuge in Cooper County, Missouri. Figure 1 shows the site as it appeared in 1879. The location consisted of a braided channel with many islands and sandbars. Historically, the channel migrated laterally across the wide floodplain, driven by large fluctuations in flow and the subsequent sediment load (NRC 2002).

In 2000, a chute was constructed at Overton Bottoms Mitigation Site as shown in Figure 2. This chute was 9,800 feet long, and was approximately 85% of the corresponding length of the river from the inlet to the outlet. The design was a pilot channel, with a bottom width of 6 feet and 2:1 side slopes. The intent of the design was that the relatively narrow pilot channel would widen to a stable width through degradation of the channel bottom and sides. The invert elevation of the chute was constructed to a relatively high elevation of 3 feet above normal navigation. This invert elevation allowed water to move through the channel only three times since it was built. Due to the narrow width, large bends in the alignment, and flow in the overbank area, severe accumulation of large woody debris occurred during flood events.

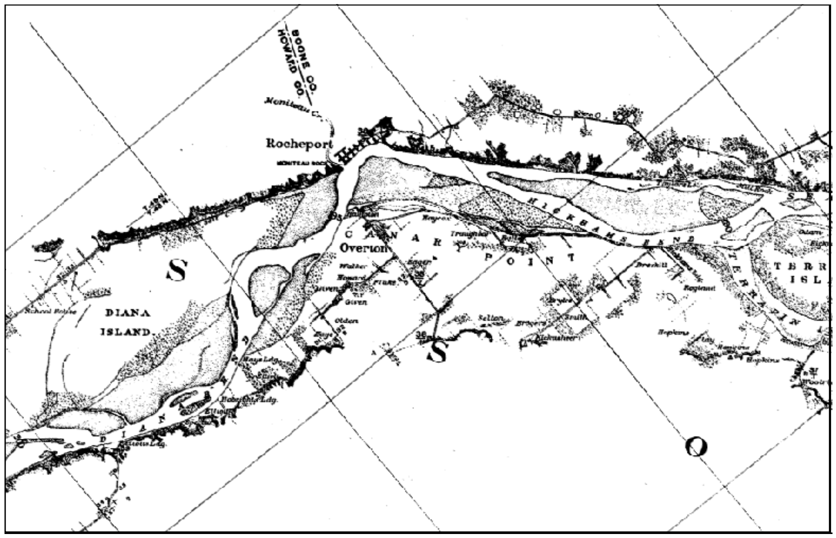

Figure 1. Overton Bottoms circa 1879

Modifications

Construction of a much larger cross section and realignment for part of the chute began in January 2003. The new design is shorter, 8,200 feet, and has a much more direct path from the inlet to the outlet. The ratio of the length of the chute to the length of the river is 0.81. The bottom slope of the chute is 0.02%, which does not differ greatly from the original alignment. The invert elevation was lowered to 4 feet below normal navigation and the cross sectional geometry has been altered. The new bottom width is 40 feet with nearly vertical walls extending from the bottom 6 feet and 1:1 side slopes to the ground surface, as shown in Figure 3.

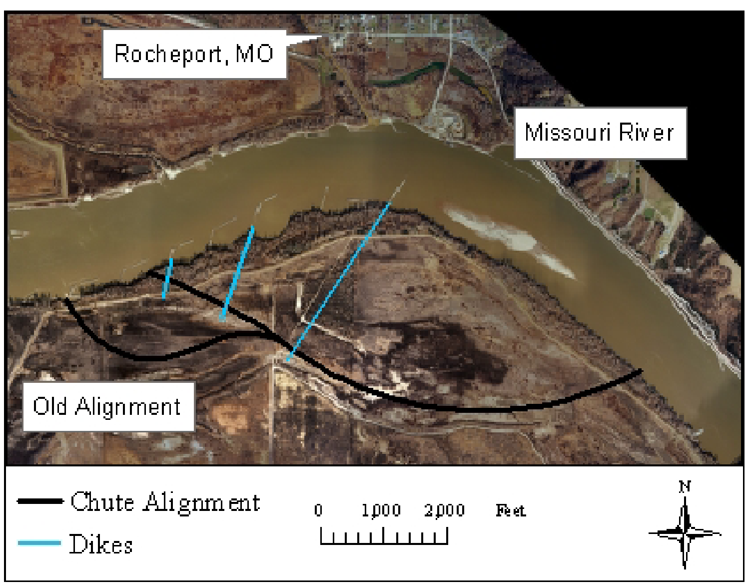

Figure 2. Overton Bottoms Mitigation Site

Three existing pile dike structures that act as grade control extend from the river and intersect the alignment of the chute. Additional riprap was placed at the second structure, approximately 1,300 feet downstream of the inlet, to provide additional stability and prevent excessive channel migration. The entrance of the chute was excavated to the same width as the typical cross section; this was done to minimize large woody debris entering the chute.

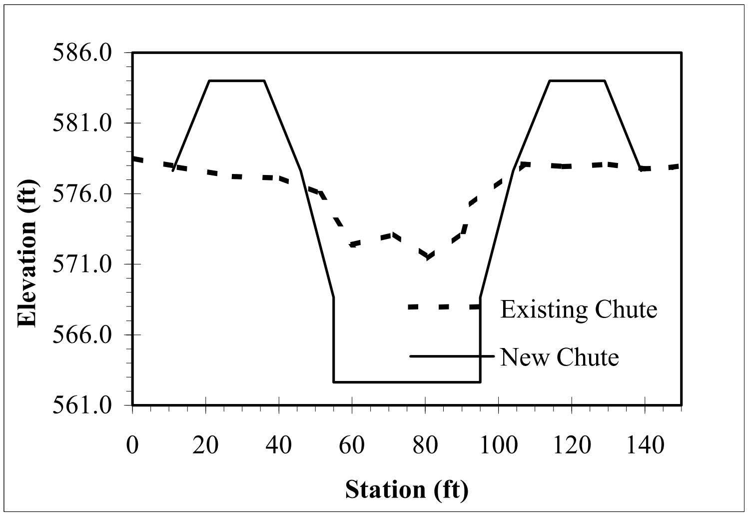

Figure 3. Overton Bottoms side chute typical cross-section

This design was intended to create an unstable channel with conditions that allow the chute to widen. Large flows will be contained in the chute to minimize debris accumulation until a stable geometry is reached due to erosion of the steep banks. As the chute widens, the spoil placed on either side of the chute will be transported into the river at a slow rate. Water will flow into the chute more often due to the lower invert elevation. The construction tolerances were also relaxed to expedite construction time and allow additional flow turbulence to aid in development of the chute. The tolerances were ± 0.5 feet on the chute bottom and ± 2 feet in the chute sides.

In order to ensure that sufficient flows and stages are maintained in the river for navigation, a HEC-RAS study was performed to estimate the amount of water diverted from the river into the chute for three flows. The model was first prepared by a contractor to model the original alignment (HDR 1998), and then modified by the Kansas City District to evaluate the altered alignment and cross sectional geometry. The model results, shown in Table 1, indicate that the flows diverted into the chute are less than 1% of the total flow for each case. The change in Missouri River stage with and without the chute was less than 0.1 ft for each flow rate, indicating that navigation flows will not be impacted by flows diverted into the chute.

Table 1. Overton Bottoms HEC-RAS Results

	Q (cfs)	Velocity (ft/sec)	Hydraulic Depth (ft)
Chute	185	1.6	3.0
Missouri River	49,815	4.9	10.1
Chute	450	2.2	5.2
Missouri River	67,050	5.5	11.0
Chute	760	2.6	7.0
Missouri River	85,240	6.0	12.4

Several other structure modifications have been made at the site. These modifications include large notches, which flank the dike into the bank line. Eight notches have been constructed that are about 50 feet wide, and are typically 4 feet below normal navigation. The surface of these notches has also been irregular to create additional turbulence and bank failure. The intent of these modifications is to allow additional water to flow around the dikes and possibly erode the banks. An example of this work is shown in Figure 4 in a photo that was taken during a low river stage. At higher stages water flows more directly behind the structure towards the bank.

Figure 4. Dike notching at Overton Bottoms Mitigation Site

Program Challenges

Several difficulties have been encountered during this and other shallow water habitat projects. Existing roads, power cables, and underground utilities have been encountered and the district has worked to avoid impacting this infrastructure. The excavation and placement of spoil piles creates water quality permitting issues that have been resolved by working closely with state and federal regulatory agencies. Local landowners have at times been against this type of work and are concerned that private land adjacent to the river may not be protected. The navigation industry has also expressed concerns that the navigation channel will be negatively impacted. The Kansas City District Project Delivery Team (PDT) has worked with state and federal agencies, contractors, the navigation industry, and landowners to address these issues.

The amount of shallow water habitat restored through structure modifications and chute construction is difficult to quantify. A monitoring effort is needed to assess the amount of shallow water habitat that is present and to identify the type of work that will restore the most habitat. There is also great uncertainly regarding the biology of the Pallid Sturgeon and the optimal conditions it requires for spawning. According to the NRC (2002), the uncertainty of the ecosystems response to restoration attempts is likely to be the greatest unknown in the mitigation effort.

Conclusions

The Kansas City District will continue to restore aquatic habitat to support the Water Resources Development Act and the U.S. Fish and Wildlife Service biological opinion. Additional work is planned at other locations that will incorporate some of the methods used at Overton Bottoms. The district intends to increase the amount and diversity of aquatic habitat along the lower Missouri River by redesigning each site in a site-specific manner. These types of projects will enable the Corps and other stakeholders to restore some aspects of the Missouri River that have been lost due to past channelization efforts.

Acknowledgements

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